भारतीय मानक
Indian Standard

IS 8654 : 2019

स्वचलित हाईड्रोलिक ब्रेक तरल, भारी ड्यूटी — विशिष्टि

(तीसरा पुनरीक्षण)

Automotive Hydraulic Brake Fluid, Heavy Duty — Specification

(Third Revision)

ICS 75.120

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Lubricants and their Related Products Sectional Committee, PCD 25

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Lubricants and their Related Products Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

Earlier there were two Indian Standards on hydraulic brake fluids, namely IS 317 : 1970 for moderate duty and IS 8654 : 1977 for heavy duty. To ensure better safety of vehicles in the increased traffic density areas, Committee decided to withdraw IS 317 and promote the use of heavy duty brake fluid.

This Indian Standard was originally prepared in 1977 based on SAE J 1703(3) 'Motor vehicle brake fluids', published by the Society of Automotive Engineers, USA, and was revised in 1986 and 2001. This standard was initially revised in 1986 in order to update and align with the requirements stipulated in Federal Motor Vehicle Safety Standard (FMVSS) No.116, DOT-3. In the second revision (2001), two more types of super heavy duty automotive brake fluids have been incorporated as Type II and Type III corresponding to DOT-4 and DOT-5.1 of FMVSS No. 116 October 1998 and SAE J 1703 January 1995 in addition to the existing DOT-3 brake fluid as Type I. These super heavy-duty automotive brake fluids have higher equilibrium reflux boiling points and wet equilibrium reflux boiling points to cope up with the severe conditions existing in the recently introduced newer models of automobiles. The superior boiling properties of these new automotive hydraulic brake fluids will provide smoother and safer stoppage of these vehicles. DOT-5 type automotive hydraulic brake fluids, which are based on silicone chemistry, are not covered by this standard. These silicone fluids are not compatible with glycol/ glycol ether based fluids.

This third revision is based on the latest FMVSS No. 116, SAE J 1703-2016 and SAE J 1704-2016 and provision for shelf life and reference to viscosity measurement of the brake fluid sample by Stabinger viscometer are included.

The composition of the technical committee responsible for the formulation of this standard is given in Annex P.

For the purpose of decided whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant placed retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AUTOMOTIVE HYDRAULIC BRAKE FLUID, HEAVY DUTY — SPECIFICATION

(Third Revision)

1 SCOPE

This standard prescribes the requirements and methods of sampling and test for non-petroleum type heavy duty automotive hydraulic brake fluid for use in hydraulic brake systems fitted with drum, disc or either type of brakes at wide ambient temperatures. These fluids are designed for use in braking systems fitted with rubber cups and seals made from styrene butadiene rubber (SBR).

2 REFERENCES

The following Indian Standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
323 : 2009	Rectified spirit for industrial use (*second revision*)
410 : 1977	Cold rolled brass sheet, strip and foil (*third revision*)
737 : 2008	Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes (*fourth revision*)
1070 : 1992	Reagent grade water (*third revision*)
1447 (Part 1) : 2000	Petroleum and its products — Methods of sampling: Part 1 Manual sampling (*first revision*)
1448	Methods of test for petroleum and its products
[P : 25/Sec 1] : 2018/ISO 3104 : 1994	Determination of kinematic and dynamic viscosity (*first revision*)
[P : 41] : 2019/ ISO 9030 : 1990	Water and sediment in crude oils and fuel oils by centrifuge (*second revision*)
1570	Schedules for wrought steels
[P : 1] : 1978	Part 1 : Steels specified by tensile and/or yield properties (*first revision*)
2362 : 1993	Determination of water by karl fischer method — Test method (*second revision*)
2631 : 1976	*iso*-Propyl alcohol (*first revision*)
3355 : 1974	Grey iron castings for elevated temperatures for non-pressure containing parts *(first revision)*
3400 [P : 2] : 2014/ ISO 48 : 2010	Methods of test for vulcanized rubbers: Part 2 Hardness (*second revision*)
14811 : 2000	Rolled copper plate, sheet, strip and foils for general engineering purposes

3 TYPES

The material shall be of three types depending upon equilibrium reflux boiling points:

a) Type I;
b) Type II; and
c) Type III.

4 REQUIREMENTS

4.1 Appearance

The material shall be clear homogeneous liquid, free from water, dirt, suspended matter and other visible impurities.

4.2 Color

The brake fluid defined under Type I, II and III shall be dyed red for identifying the leakage easily.

NOTE — However, in case of specific requirement from the user, the color of the product may be mutually agreed to between the supplier and the user.

4.3 The material shall also meet the requirements prescribed in Table 1 when tested in accordance with the methods given in col 6 of Table 1.

4.4 The shelf life of the product may be 12 months, provided, if it is packed, sealed and stored in ambient conditions

Table 1 Requirements for Automotive Hydraulic Brake Fluid, Heavy Duty

(*Clause* 4.3)

Sl No.	**Characteristics**	**Requirements**			**Methods of test, Ref to**
		Type I	**Type II**	**Type III**	**Annex/IS 1448/ ASTM**
(1)	(2)	(3)	(4)	(5)	(6)
i)	Equilibrium reflux boiling point (ERBP),°C, *Min*	205	230	260	A
ii)	Wet equilibrium reflux boiling point,°C, *Min*	140	155	180	B
iii)	Kinematic viscosity, cSt				[P : 25 / Sec 1]1)/ D 7042
	a) At - 40°C, *Max*	1500	1800	900	-
	b) At 100°C, *Min*	1.5	1.5	1.5	
iv)	*p*H value	← 7.0 to 11.5 →			C
v)	Brake fluid stability :				D
	a) High temperature stability, change in ERBP, °C, *Max*	← 3.0 + 0.05 for each → degree above 225°C			
	b) Chemical stability, change in ERBP of mixture, °C, *Max*	← 3.0 + 0.05 for each → degree above 225°C			
vi)	Corrosion test; at 100 ± 2°C for 120 ± 2 h				E
	a) Mass change, mg/cm^2, *Max*				
	Tinned iron	← 0.2 →			
	Steel	← 0.2 →			
	Aluminum	← 0.1 →			
	Cast iron	← 0.2 →			
	Brass	← 0.4 →			
	Copper	← 0.4 →			
	b) Condition of test metal strips	← No visible pitting or etching →			
	c) Appearance of test fluid in the jar at 23 ± 5°C	← No jelling →			
	d) Crystalline deposit on the walls of test jar test metal strips	← None →			
	e) Sediments, percent by volume, *Max*	← 0.10 →			
	f) *p*H of test fluid	← 7.0 to 11.5 →			
	g) Effect on rubber cup (SBR):				
	1) Appearance	No disintegration as evidenced by blisters or sloughing			
	2) Hardness decrease (IRHD), *Max*	← 15 →			
	3) Base diameter increase in mm, *Max*	← 1.4 →			
vii)	Fluidity and appearance at low temperatures:				F
	a) at - 40 ± 2°C for 144 ± 4 h2)				
	1) Sludging, sedimentation, crystallization, or stratification	← None →			
	2) Bubble flow time, s, *Max*	← 10 →			
	b) at - 50 ± 2°C for 6 ± 0.2 h				
	1) Sludging, sedimentation, crystallization, or stratification	← None →			
	2) Bubble flow time, s, *Max*	← 35 →			
viii)	Evaporation test at 100 ± 2°C:				G
	a) Loss in percentage mass, *Max*	← 80 →			
	b) Abrasiveness or grittiness	← None →			

Sl No.	Characteristics	Requirements Type I	 Type II	 Type III	Methods of test, Ref to Annex/IS 1448/ ASTM
(1)	(2)	(3)	(4)	(5)	(6)
	c) Flow of residue at -5°C for 5 s, in mm, *Min*		← 5 →		
ix)	Water tolerance test:				H
	a) at - 40 ± 2°C for 120 ± 2 h				
	1) Clarity		← Clear →		
	2) Sludging, sedimentation, crystallization, or stratification		← None →		
	3) Bubble flow time, s, *Max*		← 10 →		
	b) at 60 ± 2°C for 24 ± 2 h				
	1) Stratification		← None →		
	2) Sediments, percent by volume, *Max*		← 0.15 →		
x)	Compatibility test:				J
	a) at - 40 ± 2°C for 24 ± 2 h				
	1) Clarity		← Clear →		
	2) Sludging, sedimentation, crystallization, or stratification		← None →		
	b) at 60 ± 2°C for 24 ± 2 h				
	1) Stratification		← None →		
	2) Sediments, percent by volume, *Max*		← 0.05 →		
xi)	Resistance to oxidation:				K
	a) Change in mass, mg/cm^2, *Max*				
	1) Aluminum		← 0.05 →		
	2) Cast Iron		← 0.30 →		
	b) Condition of metal strips		No visible pitting or etching and no gummy deposits		
xii)	Effects on rubber cups (SBR):				L
	a) at 70 ± 2°C for 70 ± 2 h				
	1) Base diameter increase, mm		← 0.17 to 1.6 →		
	2) Hardness decrease, IRHD, *Max*		← 10 →		
	3) Appearance		No disintegration is evidenced by blisters or sloughing and stickness		
	b) at 120 ± 2°C for 70 ± 2 h				
	1) Base diameter increase, mm		0.15 to 1.4		
	2) Hardness decrease, IRHD, *Max*		← 15 →		
	3) Appearance		No disintegration is evidenced by blisters or sloughing and stickness		
xiii)	Simulated performance test (stroking properties)		← Shall pass the test →		M

NOTES:

1 In case of disputes P : 25/Sec1 shall be the referee method.

2 Test at Sl. No. vii a) shall be taken as type test

5 PACKING AND MARKING

5.1 Packing

The material shall be securely closed and packed in containers of metal or any suitable material as agreed to between the purchaser and the supplier.

5.2 Marking

5.2.1 Material shall be marked with the following information:

a) Name and type of material;

b) Manufacturer's name, initials or trade-mark, if any;

c) Net mass of material;

d) Identification in code or otherwise to enable the lot of consignment or manufacture to be traced back from records; and

e) Any other statutory requirement.

5.2.2 *BIS Certification Marking*

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed there under, and the products may be marked with the standard mark.

6 SAMPLING

Representative samples of material shall be drawn as prescribed in IS 1447 (Part 1).

ANNEX A

[*Table* 1, *Sl No.* (i)]

EQUILIBRIUM REFLUX BOILING POINT (ERBP)

A-1 GENERAL

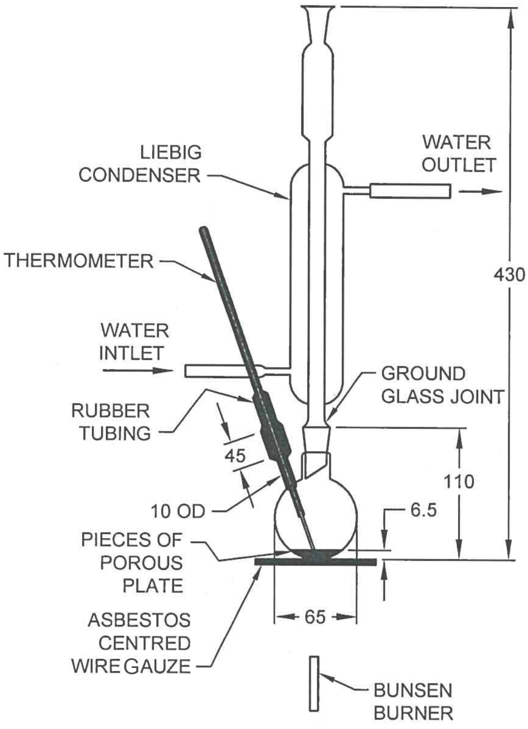
Determine the ERBP of the brake fluid by running duplicate samples according to the following procedure and averaging the results.

A-2 OUTLINE OF METHOD

60 ml of brake fluid is boiled under specified equilibrium conditions (reflux) at atmospheric pressure in 100 ml flask. The average temperature of the boiling fluid at the end of the reflux period, corrected for variations in barometric pressure if necessary, is the ERBP.

A-3 APPARATUS

The test apparatus shall consist of the following (*See* Fig. 1):



All dimensions in millimetres

FIG. 1 ASSEMBLY OF APPARATUS FOR DETERMINATION OF EQUILIBRIUM REFLUX BOILING POINT AND TEST FOR STABILITY

a) *Flask* (*see* Fig. 2) — A 100 ml round bottom, short-neck heat resistant glass flask having a neck with a 19/38 standard taper, female ground glass joint and a side-entering tube with an outside diameter of 10 mm which centers the thermometer bulb in the flask 6.5 mm from the bottom;

b) *Condenser* — A water-cooled, reflux, glass tube type condenser-having a jacket 200 mm in length, the bottom end of which have a 19/38 standard-taper, drip-tip, male ground glass joint;

c) *Boiling Stones* — Three clean, unused silicon carbide grains (approximately 2 mm in diameter, grit No. 8);

d) *Thermometer Standardized* — Calibrated partial immersion (76 mm) solid stem, thermometers conforming to the following requirements:

Details	*Type I*	*Type II*
Length	15.4 in (390 mm)	16.3 in (415 mm)
Total measurement range	-5 to 300°C	-5 to 400°C
Graduation	1.0°C	1.0°C
Immersion length	3 in (76mm)	3in (76 mm)

NOTE — Thermometers of ASTM 2C and ASTM 3C grades may also be used.

e) *Heat Source* — Variable autotransformer controlled heating mantle designed to fit the flask, or an electric heater with rheostat heat control.

A-4 PREPARATION OF APPARATUS

a) Thoroughly clean and dry all glassware.

b) Insert thermometer through the side tube until the tip of the bulb is 6.5 mm from the bottom centre of the flask. Seal with a short piece of natural rubber, SBR or butyl tubing.

c) Place 60 ± 1 ml of brake fluid and the silicon carbide grains into the flask.

d) Attach the flask to the condenser. When using a heating mantle, place the mantle under the flask and support it with a ring-clap and laboratory type stand, holding the entire assembly in place by a clamp. When using a rheostat-controlled heater, centre a standard porcelain or hard asbestos refractory, having a diameter opening 32 to 38 mm over the heating element and mount the flask so that the direct heat is applied only through the opening in the refractory. Place the assembly in an area free from drafts or other types of sudden temperature changes. Connect the cooling water inlet and outlet tubes to the condenser. Turn on the cooling water. The water supply temperature shall not exceed 28°C and temperature rise through the condenser shall not exceed 28°C.

A-5 PROCEDURE

Apply heat to the flask so that within 10 ± 2 min the fluid is refluxing in excess of 1 drop per second. The reflux rate shall not exceed 5 drops per second at any time. Immediately adjust the heating rate to obtain an equilibrium reflux rate of 1 to 2 drops per second over the next 5 ± 2 min. Maintain this rate for an additional 2 min, taking four temperature readings at 30 s intervals. Record the average of these as the observed ERBP. If no reflux is evident when the fluid temperature reaches 260°C, discontinue heating and observe the ERBP as in excess of 260°C. Record the barometric pressure.

A-6 CALCULATION AND REPORTING

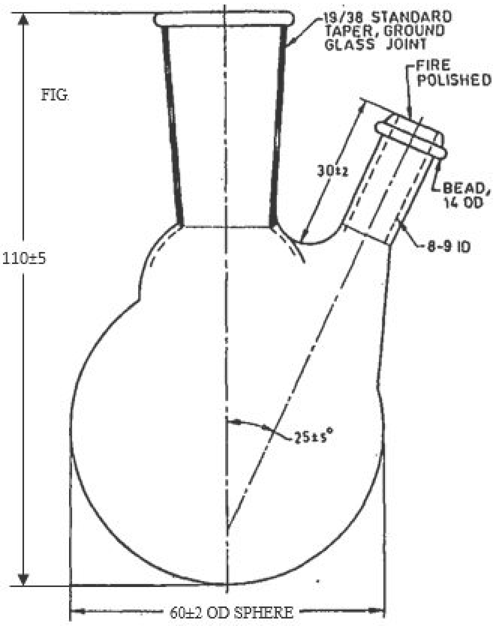
A-6.1 Variation from Standard Barometric Pressure

Apply the factor shown in Table 2 to calculate the barometric pressure correction to the ERBP**.**

Table 2 Correction for Barometric Pressure
(*Clause* **A-6.1**)

Sl No.	**Observed ERBP, °C**	**Correction per 1 mm Difference in Pressure[1], °C**
(1)	(2)	(3)
i)	100 to 190°C	0.039
ii)	Over 190°C	0.04

[1] To be added in case barometric pressure is below 760 mm; to be subtracted in case barometric pressure is above 760 mm.



All dimensions in millimeters.

FIG. 2 DETAILS OF 100 ML SHORT-NECK FLASK

A-6.2 If the two corrected observed ERBP's agree within 2.0°C (4.0°C for brake fluids having an ERBP over 230°C) average the duplicate runs as the ERBP; otherwise, repeat the entire test, averaging the four corrected observed values to determine the original ERBP.

ANNEX B

[*Table* 1, *Sl No.* (ii)]

WET EQUILIBRIUM REFLUX BOILING POINT (ERBP)

B-1 GENERAL

Determine the wet ERBP of brake fluid by running duplicate samples according to the following procedure and averaging the results.

B-2 OUTLINE OF THE METHOD

A 350 ml sample of the brake fluid is humidified under controlled conditions, 350 ml of TEGME (triethylene glycol monomethyl ether), is used to establish the end point for humidification. After humidification, the water content and ERBP of the brake fluid are determined.

B-3 APPARATUS FOR HUMIDIFICATION

Test apparatus shall consist of the following (*See* Fig. 3):

a) *Glass Jars* — Four SAE RM-49 corrosion test jars or equivalent screw top, straight-sided, round glass jars each having a capacity of about 475 ml and approximate inner dimensions of 100 mm in height by 75 mm in diameter, with matching lids having new, clean inserts providing water-vapour-proof scales.

b) *Desiccator and Cover* — Two bowl form glass desiccators, 250 ± 10 mm inside diameter, having matching tubulated covers fitted with suitable rubber stoppers.

c) *Desiccator Plate* — Four 230 ± 10 mm diameter, perforated porcelain desiccator plates, without feet, glazed on one side.

B-4 REAGENTS AND MATERIALS

a) *Distilled Water* — *See* IS 1070.

b) *TEGME (Triethylene Glycol Monomethyl Ether)*

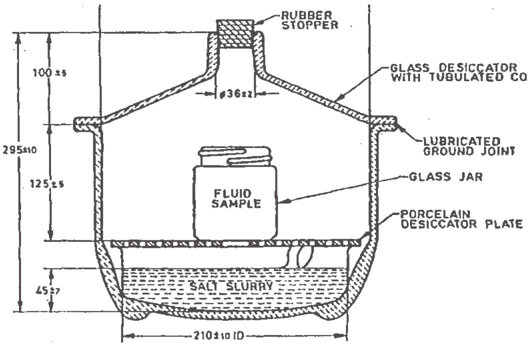
Sl No.	*Characteristics*	*Requirement*
1	Appearance	Clear liquid, without any suspended matter
2	Assay, percent, *Min*	94
3	Water content, percent by weight, *Max*	0.3
4	ERBP, *Min*	240°C
5	Acidity, percent by weight, *Max*	0.02

B-5 PREPARATION OF APPARATUS

Lubricate the ground glass joint of the desiccator. Pour 450 ± 10 ml of the distilled water into each desiccator and insert perforated porcelain desiccator plate. Place the desiccator in an oven with temperature controlled at 50 ± 2°C throughout the humidification procedure.

B-6 PROCEDURE

Pour 350 ± 5 ml of the brake fluid into and open corrosion test jar. Prepare in same manner a duplicate test fluid sample, and two duplicate specimens of the TEGME referee material The water content of the TEGME fluid is adjusted to 0.50 ± 0.05 percent by mass at the start of the test in accordance with IS 2362. Place one sample each of the test brake fluid and the prepared TEGME sample into the same desiccator. Repeat for the second sample of test brake fluid and TEGME in a second desiccator. Place the desiccators in the 50°C controlled oven and replace desiccator covers. At intervals during oven humidification, remove the rubber stopper in the top of each desiccator. Using a long needled hypodermic syringe, take a sample of not more than 2 ml from each TEGME sample and determine water content. Remove no more than 10 ml of the fluid from each TEGME sample during the humidification procedure. When the water content of the TEGME fluid reaches 3.70 ±.05 percent by mass (average of the duplicates), removes the two test fluid specimens from their desiccators and promptly cap each jar tightly. Allow the sealed jars to cool for 60 to 90 min at 23 ± 5°C. Measure the water contents of the test fluid specimens in accordance with IS 2362 and determines their ERBP's in accordance with **A-1**. If the two ERBP's agree within 4°C, average them to determine the wet ERBP; otherwise repeat and average the four individual ERBP's as the wet ERBP of the brake fluid.



All dimensions in millimetres.

FIG. 3 HUMIDIFICATION APPARATUS

ANNEX C

[*Table* 1, *Sl No.* (iv)]

*p*H VALUE

C-1 PROCEDURE

Tests shall be carried out on material as received as well as on the material as obtained after corrosion test (Annex E).

C-1.1 Mix an equal volume of the material and mixture (50 : 50 ethanol : distilled water) of rectified spirit (IS 323) and water (IS 1070). The mixture of rectified spirit and water shall be adjusted to a *p*H of 7.0 before mixing it with the material. Determine the *p*H of the final mixture at 23°C.

C-1.2 The *p*H may be determined by either electrometric method or indicator method. In case of dispute, the electrometric method shall be adopted.

ANNEX D

[*Table* 1, *Sl No.* (v)]

FLUID STABILITY

D-1 SUMMARY OF THE METHOD

The degradation of brake fluid at elevated temperature alone or in a mixture with a reference fluid is evaluated by determining the change in ERBP after a period of heating under reflux conditions.

D-2 APPARATUS

Same as specified in Annex A.

D-3 PROCEDURE FOR HIGH TEMPERATURE STABILITY

D-3.1 Heat a new 60 ± 1 ml sample of the brake fluid to 185 ± 2°C. Hold at this temperature for 120 ± 5 min. Bring to a reflux rate in excess of one drop per second within 5 min. The reflux rate should not exceed five drop per second at any time. Over the next 5 ± 2 min adjust the heating rate to obtain an equilibrium reflux rate of 1 to 2 drops per second. Maintain this rate for an additional two min taking 4 temperature readings at 30 s intervals. Average these as the observed ERBP. If no reflux is evident when the fluid temperature reaches 260°C, discontinue heating and observe the ERBP as in excess of 260°C. Record the barometric pressure.

D-3.2 Calculation and Reporting

Correct the observed ERBP for barometric pressure factors in accordance with Table 2. Average the corrected ERBP's of the duplicate samples. The difference between this average and the original ERBP obtained in **A-1** is the change in ERBP of the fluid.

D-4 PROCEDURE FOR CHEMICAL STABILITY

D-4.1 Mix 30 ± 1 ml sample of the brake fluid with 30 ± 1 ml of compatibility fluid in a boiling point flask (Annex A). Determine the initial ERBP of the mixture by applying heat to the flask so that the fluid is refluxing in 10 ± 2 min at a rate in excess of one drop per second, but not more than five drops per second.

Note the maximum fluid temperature observed during the first minute after the fluid begins refluxing at a rate in excess of one drop per second. Over the next 15 ± 1 min adjust and maintain the reflux rate at 1 to 2 drops per second. Maintain this rate for an additional two minutes recording the average value of four temperature readings taken at 30 s intervals as the final ERBP.

D-4.2 Calculation and Reporting

The difference between initial ERBP and final average temperature is the change in temperature of the refluxing mixture. Average the results of the duplicates to the nearest 0.5°C.

ANNEX E

[*Table* 1, *Sl No.* (vi)]

CORROSION TEST

E-1 OUTLINE OF THE METHOD

Six specified metal corrosion test strips are polished, cleaned and weighed then assembled as described. Assembly is placed on a standard wheel cylinder cup in corrosion test jar immersed in the water-wet brake fluid, capped and placed in an oven at 100°C for 120 h. Upon removal and cooling the strips, fluid and cups are examined and tested.

E-2 EQUIPMENT

E-2.1 Balance

An analytical balance having a minimum capacity of 50 g and capable of weighing to the nearest 0.1 mg.

E-2.2 Desiccators

Desiccators containing silica gel or other suitable desiccant.

E-2.3 Oven

Gravity convection oven capable of maintaining the desired set point within 2°C.

E-2.4 Micrometer

A machinist's micrometer 25 to 50 mm capacity, or an optical comparator, capable of measuring the diameter of the SBR wheel cylinder (WC) cup to the nearest 0.02 mm.

E-3 MATERIALS

E-3.I Corrosion Test Strips

Test strips shall be 80 mm long, 13 mm wide, and not more than 6 mm thick with a hole of 4-5 mm diameter drilled at about 6 mm from one end of the strip. The metal strips shall be of tinned iron steel, aluminium, cast iron, brass and copper conforming to the following description and specifications:

a) *Tinned Iron* — The strip shall be free from laminations, blisters, sliver, rolled-in-scale, pits, ragged edges, holes turn down corners, black or white edges, scruffy metal, uncoated spots or other defects. The mass of tin coating, both sides taken together shall not be less than 27 g/m^3.

b) *Steel* — The strips shall be made from alloy steel sheet (cold rolled), which shall be free from seams, laminations, blisters, excessive detachable scales and other defects. The steel shall conform to designation **10** of IS 1570 (Part 1) and with the phosphorus (as P) and sulphur (as S) limited to 0.04 percent and 0.050 percent maximum, respectively.

c) *Aluminium Alloy* — The strip shall be made from annealed aluminium alloy sheet which shall be uniform in quality and condition, sound, smooth, flat, free from buckles and other defects. The alloy shall conform to grade H14 of IS 737.

d) *Cast Iron* — The strip shall be made from grey cast iron conforming to grade 1 of IS 3355 or from a brake cylinder of known make.

e) *Brass* — The strip shall be made from brass sheet conforming to grade CuZn30 of IS 410. The sheet shall be clean, smooth flat and free from temper. The sheet shall also be free from foreign material, pipes, laps, slivers cracks, scales, buckles and other defects.

f) *Copper* —The strip shall be made from the light cold rolled copper sheet. The copper content shall not be less than 99.9 percent (*see* IS 14811), silver, if any, being taken as copper.

E-3.2 SBR Cups

Two unused standard wheel cylinder (WC) cups of diameter approximately 32 mm.

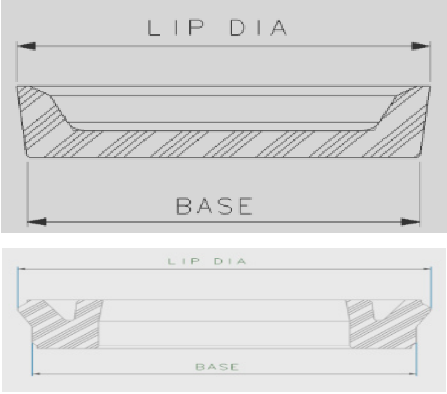


FIG. 4 SBR CUPS

NOTE — SBR rubber compound formulation and (Specifications of SBR shall be as per SAE J 1703/1704) Part no. TVS GIRLING 64674047 cup.

E-3.3 Corrosion Test Jars and Lids

Two screw top straight sided round glass jars, each having a capacity of approximately 475 ml and inner dimensions of approximately 100 mm in height and 75 mm in diameter and a tinned steel lid (no insert or organic coating) vented with a hole 0.8 ± 0.1 mm in diameter.

E-3.4 Machine Screws and Nuts

Clean, rust and oil-free uncoated mild steel round or fillister head machine screw of approximately 18 mm length and matching uncoated nuts.

E-3.5 Supplies for Polishing Strips

Waterproof silicon carbide paper, grit No. 320, grade 00 steel wool, lint-free polishing cloth.

E-3.6 Distilled Water, *see* IS 1070.

E-3.7 *Iso*-propanol, *see* IS 2631.

E-4 PROCEDURE

E-4.1 Except for the tinned iron strips, abrade corrosion test strips on all surface areas with silicon carbide paper wet with *iso*-propanol until all surface scratches, cuts and pits are removed. Use a new piece of paper for each different type of metal; polish the strips with the 00 grade steel wool. Wash all strips, including the tinned iron and the assembly hardware, with *iso*-propanol; dry the strips and assembly hardware with a clean lint-free cloth or use filtered compressed air and place the strips and hardware in a desiccator containing silica gel or other suitable desiccant and maintained at 23 ± 5°C for at least one hour. Handle the strips with forceps after polishing. Weigh and record the mass of each strip to the nearest 0.1 mg.

Assemble the strips on a clean dry machine screw, with matching plain nut, in the order of tinned iron, steel, aluminium, cast iron, brass and copper. Bend the strips, other than the cast iron, so that there is a separation of 3 ± 0.5 mm between adjacent strips for a distance of about 5 cm from the free end of the strips (*see* Fig. 5). Tighten the screw on each test strip assembly so that the strips are in electrolytic contact and can be lifted by either of the outer strips (tinned iron or copper) without any of the strips moving relative to the others when held horizontally. Immerse the strip assemblies in *iso*-propanol. Dry with dried filtered compressed air, then desiccate at least one hour before use.

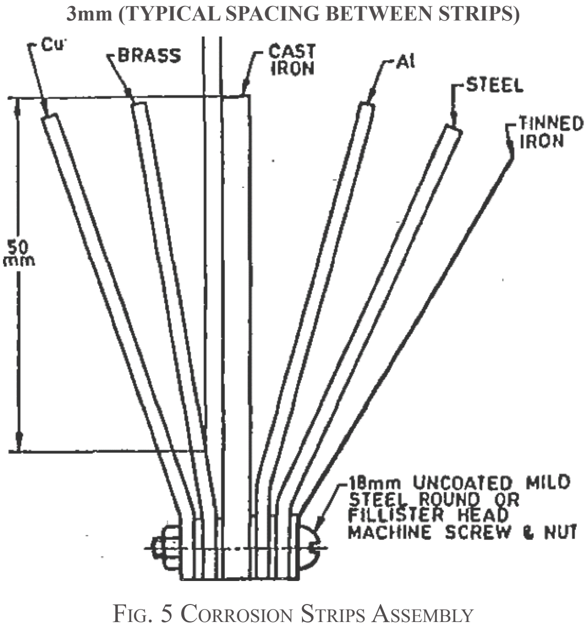

3mm (TYPICAL SPACING BETWEEN STRIPS)
Cu
BRASS
CAST IRON
Al
STEEL
TINNED IRON
50 mm
18mm UNCOATED MILD STEEL ROUND OR FILLISTER HEAD MACHINE SCREW & NUT

FIG. 5 CORROSION STRIPS ASSEMBLY

E-4.2 Measure the base diameters of the 2 standard SBR cups using an optical comparator or micrometer to the nearest 0.02 mm along the centerline at right angles to this centerline. Take the measurements at least 0.4 mm above the bottom edge and parallel to the base of the cup. Discard any cup if the two measured diameters differ by more than 0.08 mm. Average the two readings on each cup. Determine the hardness of the cups by the method given in IS 3400 (Part 2).

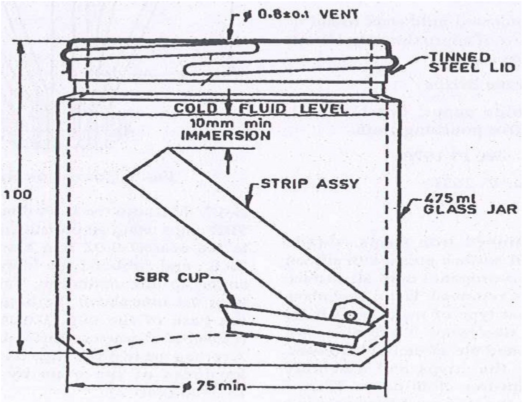
E-4.3 Rinse the cups in *iso*-propanol for not more than 30 s and wipe dry with a clean lint free cloth. Place one cup with lip edge facing up in each jar. Insert a metal strip assembly inside each cup with the fastened end down and the free end extending upward (*see* Fig. 6). Mix 760 ml of brake fluid with 40 ml of distilled water. Using this water wet mixture; cover each strip assembly to a minimum depth of 10 mm above the tops of the strips. Tighten the lids and place the jars for 120 ± 2 h in an oven maintained at 100 ± 2°C. Allow the jars to cool at 23 ± 5°C for 60 to 90 min. Immediately remove the strips from the jars using forceps, agitating the strip assembly in the fluid to remove adhering sediment. Examine the test strips jars for adhering crystalline deposits. Disassemble the metal strips and remove adhering fluid by flushing with water, clean each strip by wiping with a clean cloth wetted with *iso*-propanol. Examine the strips for evidence of corrosion and pitting.

E-4.4 Disregard staining or discoloration. Place the strips in a desiccator maintained at 23 ± 5°C for at least 1 h. Weigh each strip to the nearest 0.1 mg. Determine the change in mass of each metal strip. Average the results for the two strips of each type of metal. Immediately following the cooling period remove the cups from the jars with forceps. Remove loose adhering sediment by agitation of the cups in the mixture, rinse the cups in *iso*-propanol and air-dry. Examine the cups for evidence of sloughing, blisters, and other forms of disintegration. Measure the base diameter and hardness of each cup within 15 min after removal from the mixture. Examine the mixture for gelling. Agitate the mixture to suspend and uniformly disperse sediment. From each jar, transfer a 100 ml portion of the mixture to a cone shaped centrifuge tube and determine the percent sediment by the method given in IS 1448 [P : 41]. Further, measure the *p*H value of the test mixture according to Annex C.

E-5 CALCULATION AND REPORTING

E-5.1 Measure the area of each type of test strip to the nearest square centimeter. Divide the average change in mass for each type by the area of that type.

E-5.2 Note other data and evaluations indicating compliance with Sl No. (vi) of Table 1. In the event of a marginal pass on inspection by attributes, or of a failure in one of the duplicate, run another set of duplicate samples. Both repeat samples shall meet all requirements given in Table 1.



All dimensions in millimeters

FIG. 6 CORROSION TEST APPARATUS

ANNEX F

[*Table* 1, *Sl No.* (vii)]

FLUIDITY AND APPEARANCE AT LOW TEMPERATURES

F-1 OUTLINE OF THE METHOD

Brake fluid is chilled to the expected minimum exposure temperatures and observed for clarity, gelation, and sediment, separation of components, excessive viscosity or thixotropy.

F-2 APPARATUS

F-2.1 Oil Sample Bottle

Two clear flint glass bottles of approximately 125 ml capacity, an outside diameter of 37.0 ± 0.05 mm and an overall height of 165 ± 2.5 mm.

F-2.2 Cold Chamber

An air bath cold chamber capable of maintaining storage temperatures, down to -55°C with an accuracy of ± 2°C.

F-2.3 Timing Device

A suitable timing device.

F-3 PROCEDURE

F-3.1 Place 100 ± 1 ml of brake fluid at room temperature in an oil sample bottle. Stopper the bottle with an unused cork and place in the cold chamber maintained at -40 ± 2°C. After 144 ± 4 h remove the bottle from the chamber, quickly wipe it with a clean, lint-free cloth, saturated with *iso*-propanol. Examine the fluid for evidence of sludging, sedimentation, crystallization, or stratification. Invert the bottle and determine the number of seconds required for the air bubble to travel to the top of the fluid. Let sample warm up to room temperature and examine.

F-3.2 Repeat the above procedure with the cold chamber maintained at -50 ± 2°C for a period of 6 h ± 12 min.

F-3.3 Test specimens from either storage temperature may be used for the other only or after warming up to room temperature.

ANNEX G

[*Table* 1, *Sl No.* (viii)]

EVAPORATION TEST

G-1 OUTLINE OF THE METHOD

The volatile diluents portion of a brake fluid is evaporated in an oven at 100°C. The non-volatile lubricant portion (evaporation residue) is measured and examined for grittiness; the residues are then combined and checked to assess fluidity at -5°C.

G-2 APPARATUS

G-2.1 Petri Dishes

Four covered glass petri dishes approximately 100 mm in diameter and 15 mm in height.

G-2.2 Oven

A top vented gravity convection oven capable of maintaining a temperature of 100 ± 2°C.

G-2.3 Balance

A balance having a capacity of at least 100 g capable of weighing to the nearest 0.01 g and suitable for weighing petri dishes.

G-2.4 Oi1 Sample Bottle

A glass sample bottle as described in **F-2.1.**

G-2.5 Cold Chamber

Air bath cold chamber capable of maintaining a temperature of -5 ± 1°C.

G-2.6 Timing Device

A suitable timing device.

G-3 PROCEDURE

Obtain the tare mass of each of the four covered petri dishes to the nearest 0.01 g. Place 25 ± 1 ml of brake fluid in each dish, replace proper covers and reweigh. Determine the mass of each brake fluid test specimen by the difference. Place the four dishes, each inside its inverted cover, in the oven at 100 ± 2°C for 46 ± 2 h (*see* Note). Remove the dishes from the oven, allow to cool to 23 ± 5°C and weigh. Return to the oven for an additional 24 ± 2 h. If at the end of 72 ± 4 h the average loss by evaporation is less than 60 percent, discontinue the evaporation procedure and proceed with examination of residue. Otherwise, continue this procedure either until equilibrium is reached as evidenced by an incremental mass loss of less than 0.25 g in 24 h on all individual dishes or for a maximum of 7 days. During the heating and weighing operation, if it is necessary to remove the dishes from the oven for a period of longer than 1 h, the dishes shall be stored in a desiccator as soon as cooled to room temperature. Calculate the percentage of fluid evaporated from each dish. Examine the residue in the dishes at the end of 1 h at 23 ± 5°C. Rub any sediment with the fingertip to determine grittiness or abrasiveness. Combine the residues from all four dishes in a 125 ml sample bottle and store vertically in cold chamber at –5 ± 1°C for 60 ± 10 min. Quickly remove the bottle and place in the horizontal position. The residue shall flow at least 5 mm along the tube within 5 s.

NOTE— Do not simultaneously heat more than one fluid in the same oven.

G-4 CALCULATION AND REPORTING

G-4.1 The average of the percentage evaporated from all four dishes is the loss on evaporation.

G-4.2 Also report the other requirements given in Table 1, Sl No. (viii).

ANNEX H

[*Table* 1, *Sl No.* (ix)]

WATER TOLERANCE TEST

H-1 OUTLINE OF THE METHOD

Brake fluid is diluted with 3.5 percent water and then stored at –40°C for 120 h + 2 h. The cold water wet fluid is first examined for clarity, stratification and sedimentation, then placed in an oven at 60°C for 24 h. On removal, it is again examined for stratification and the volume percent of sediment determined by centrifuging.

H-2 PROCEDURE

H-2.1 At – 40°C — Mix 96.5 ml of test fluid and 3.5 ml of distilled water of the brake fluid and pour into a centrifuge tube. Stopper the tube with a clean cork and place in the cold chamber maintained at –40 ± 2°C. After 120 ± 2 h remove the tube, quickly wipe with clean lint-free cloth saturated with *iso*-propanol and examine the fluid, for evidence of sludging, sedimentation, crystallization or stratification. Invert the tube and determine the number of seconds required for the air bubble to travel to the top of the fluid. The air bubble is considered to have reached the top of the fluid when the top of the bubble reaches the 2 ml graduation of the centrifuge tube. If the wet fluid has become cloudy, warm to 23 ± 5°C and note appearance and fluidity.

H-2.2 At 60°C — Place tube and brake fluid from H-2.1 in an oven maintained at 60 ± 2°C for 24 ± 2 h.

Remove the tube and immediately examine the contents for evidence of stratification. Determine the percent sediment by centrifuging by the method given in IS 1448 [P : 41].

ANNEX J

[*Table* 1, *Sl No.* (x)]

COMPATIBILITY TEST

J-1 OUTLINE OF THE METHOD

Brake fluid is mixed with an equal volume of SAE compatibility fluid, then tested in the same way as for water tolerance test (Annex H) except that the bubble flow time is not measured. This test is an indication of the compatibility of the test fluid with other motor vehicle brake fluids at both high and low temperatures.

J-2 PROCEDURE

J-2.1 At - 40°C — Mix 50 ± 0.5 ml of brake fluid with 50 ± 0.5 ml of compatibility fluid. Pour this mixture into a centrifuge tube and stopper with a clean dry cork. Place tube in the cold chamber maintained at -40 ± 2°C. After 24 ± 2h, remove tube, quickly wipe with a clean lint-free cloth saturated with *iso*-propanol. Examine the fluid-mixture for evidence of sludging, sedimentation, crystallization or stratification.

J-2.2 At 60°C — Place tube and test fluid from **J-2.1** for 24 ± 2 h in an oven maintained at 60 ± 2°C. Remove tube and immediately, examine the fluid mixture for evidence of stratification. Determine percent sediment by centrifuging by the method given in IS 1448 [P: 41].

ANNEX K

[*Table* 1, *Sl No.* (xi)]

RESISTANCE TO OXIDATION

K-1 OUTLINE OF THE METHOD

Brake fluid is activated with a mixture of approximately 0.2 percent benzoyl peroxide and 5 percent water. A corrosion test strip assembly consisting of a cast iron and an aluminium strip separated by tin foil squares at each end is then rested on a piece of SBR WC cup positioned so that the test strip is half immersed in the fluid and oven aged at 70°C for 168 h. At the end of this period the metal strips are examined for pitting, etching and mass loss.

K-2 REAGENTS AND MATERIALS

K-2.1 Benzoyl Peroxide — Reagent grade 96 percent purity.

K-2.2 Corrosion Test Strips — Two sets of cast iron and aluminium metal test strips as described in Annex E.

K-2.3 Tinfoil — Four unused pieces of tinfoil approximately 12 mm square and between 0.02 and 0.06 mm in thickness. The foil shall be at least 99.9 percent tin and should not contain more than 0.025 percent lead.

K-2.4 SBR — Two, unused, approximately one-eighth sections of a standard SBR cup (*see* Annex E).

K-2.5 Machine Screw and Nut — Two, clean, oil free, 12 mm long round or fillister head, uncoated mild steel machine screws, with matching plain nuts.

K-3 PROCEDURE

K-3.1 Prepare two sets of aluminum and cast iron test strips according to Annex E except for assembly. Weigh each strip to the nearest 0.1 mg and assemble a strip of each metal on a machine screw, separating the strips at each end with a piece of tinfoil. Tighten the nut enough to hold both pieces of foil firmly in place.

K-3.2 Place 30 ± 1 ml of the brake fluid under test in 22 x 175 mm test tube. Add 0.060 ± 0.002 g of benzoyl peroxide and 1.50 ± 0.05 ml of distilled water. Stopper the tube loosely with a clean dry cork, shake and place in an oven for 2 h at 70 ± 2°C. Shake every 15 min to effect solution of the peroxide. Remove the tube from the oven and allow cooling at 23 ± 5°C. Begin testing according to **K-3.3** not more than 24 h after removal of tube from oven.

K-3.3 Place a one-eighth SBR cup section in the bottom of each test tube. Add 10 ml of prepared test mixture to each test tube. Place a metal strip assembly in each, the end of the strip without the screw resting on the rubber, and the solution covering about one-half the length of the strips. Stopper the tubes with clean dry corks and store upright for 70 ± 2 h at 23 ± 5°C. Loosen the corks and place the tubes for 168 ± 2 h in an oven maintained at 70 ± 2°C. Afterwards remove and disassemble the strips. Examine the strips and note any gum deposits. Wipe the strips with a clean cloth wet with *iso*-propanol and note any pitting, etching or roughening of surface disregarding stain or discoloration. Place the strips in a desiccator over silica gel or other suitable desiccant at 23 ± 5°C for at least 1 h. Again weigh each strip to the nearest 0.1 mg.

K-4 CALCULATION AND REPORTING

Determine corrosion loss by dividing the change in mass of each metal strip by the total surface area of each strip measured in cm^2 to the nearest cm^2. Average the results for two strips of each type of metal rounding to the nearest 0.05 mg/cm^2. If only one of the duplicates fails for any reason, run a second set of duplicate samples. Both repeat samples shall meet all the requirements given in Table 1 at Sl No. (xi).

ANNEX L

[*Table* 1, *Sl No.* (xii)]

EFFECT ON RUBBER CUPS (SBR)

L-1 OUTLINE OF THE METHOD

Four standard approximately 32 mm dia SBR WC cups (*see* Annex E) are measured and their hardness determined. The cups, two to a jar are immersed in the test brake fluid. One jar is heated for 70 ± 2 h at 70 ± 2°C and the other for 70 ± 2 h at 120 ± 2°C. Afterwards the cups are washed, examined for disintegration, remeasured and their hardness redetermined.

L-2 APPARATUS

L-2.1 Glass Jars and Lids

Two screw-top, straight sided round glass jars, each having a capacity of approximately 250 ml and inner dimensions of approximately 125 mm in height and 50 mm in diameter and a tinned steel lid (no insert or organic coating).

L-3 PROCEDURE

L-3.1 Measure the base diameters of the SBR cups described in Annex E and the hardness of each cup by the method given in IS 3400 (Part 2).

L-3.2 Wash the cups in *iso*-propanol for not longer than 30 s and quickly dry with a clean lint free cloth. Using forceps place two cups into each of the two jars, add 75 ml of brake fluid to each jar and cap tightly. Place one jar in oven maintained at 70 ± 2°C maintained for 70 ± 2 h. Place the other jar in an oven maintained at 120 ± 2°C for 70 ± 2 h. Allow each jar to cool for 60 to 90 min at 23 ± 5°C. Remove cups; wash with *iso*-propanol for not longer than 30 s and quickly dry. Examine the cups for disintegration as evidenced by stickiness, blisters or sloughing. Measure the base diameter and hardness of each cup within 15 min after removal from the fluid.

L-4 CALCULATION AND REPORTING

L-4.1 Calculate the change in base diameter for each cup. If the two values at each temperature do not differ by more than 0.10 mm, average them to the nearest 0.02 mm. If the two values differ by more than 0.10 mm repeat the test at the appropriate temperature and average the four values as the change in base diameter.

L-4.2 Calculate the change in hardness for each cup. The average of the two values for each pairs is the change in hardness.

L-4.3 Note any disintegration as evidenced by stickiness, blister or sloughing.

ANNEX M

[*Table* 1, *Sl No.* (xiii)]

SIMULATED PERFORMANCE TEST (STROKING PROPERTIES)

M-1 OUTLINE OF THE METHOD

Brake fluid is stroked under controlled conditions at an elevated temperature in a simulated motor vehicle hydraulic braking system consisting of three slave wheel cylinders and an actuating master cylinder connected by any suitable tubing. Referee standard parts are used. All parts are carefully cleaned, examined and certain measurements made immediately prior to assembly for test. During the test, temperature, rate of pressure rise, maximum pressure and rate of stroking are specified and controlled. The system is examined periodically during stroking to assure that excessive leakage of fluid is not occurring. Afterwards the system is disassembled. Metal parts and SBR cups are examined and remeasured. The brake fluid and any resultant sludge and debris are collected, examined and tested (*see* Note 1).

M-2 APPARATUS AND MATERIALS

M-2.1 The stroking test apparatus shall be assembled as shown in Fig. 7 using the following components and materials:

a) *Master Cylinder Assembly* — One cast iron housing hydraulic brake master cylinder having a diameter of approximately 32 mm and fitted with an uncoated steel stand pipe (*see* Note 2).

b) *Brake Assemblies* — Three cast iron housing straight bore hydraulic brake wheel cylinder assemblies[3] having diameters of approximately 32 mm. Three fixture units are required, including appropriate adapter mounting plates to hold the brake wheel cylinder assemblies as shown in Fig. 8, (*see* Note 3).

c) *Braking Pressure Actuating Mechanism* — A suitable actuating mechanism for applying a force to the master cylinder push rod without side thrust. The amount of force applied by the actuating mechanism shall be adjustable and capable of supplying sufficient stroke and thrust to the master cylinder to create a pressure of at least 6.86 MPa (70 kgf/cm^2) in the simulated brake system. A hydraulic gauge and pressure recorder, having a range of at least 0 to 13.73 MPa (0 to 140 kgf/cm^2), shall be installed between the master cylinder and the brake assemblies and shall be provided with a shutoff valve and with a bleeding valve for removing air from the connecting tubing. The actuating mechanism shall be designed to permit adjustable stroking rates of 1 000 ± 100 strokes per hour. A mechanical or electrical counter shall be used to record the total number of strokes.

NOTES:

1 Adapted from SAE J 1703 JAN 1980; and FMVSS No. 116 DOT-3 Specification of USA or equivalent.

2 Part No. BI Girling 29066298 Master cylinder, by M/s Brakes India Ltd, Padi Chennai 600050 or equivalent.

3 Part No. BI Girling 64674350, by M/s Brakes India Ltd, Padi Chennai 600050 or equivalent.

d) *Heated Air Bath Cabinet* — An insulated cabinet

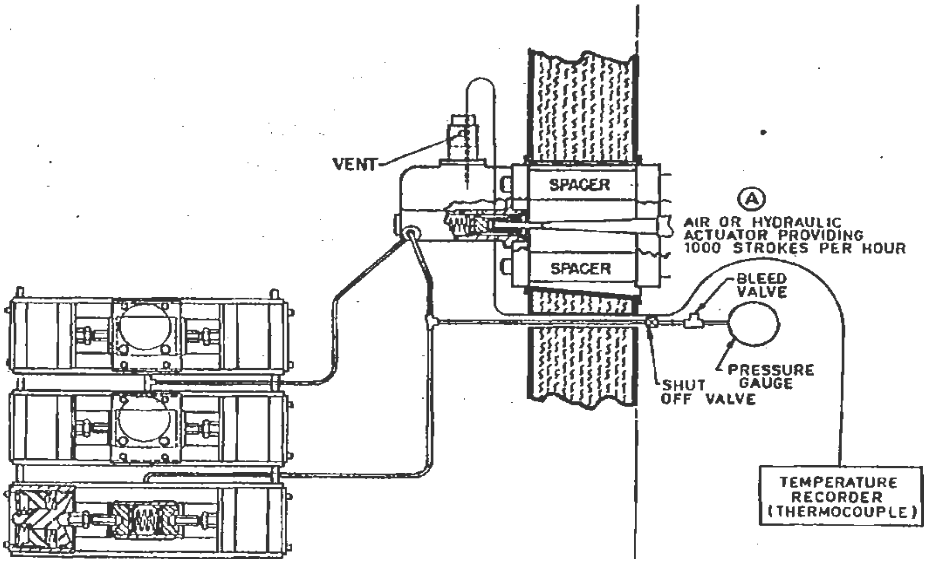

VENT
SPACER
A
AIR OR HYDRAULIC ACTUATOR PROVIDING 1000 STROKES PER HOUR
SPACER
BLEED VALVE
PRESSURE GAUGE
SHUT OFF VALVE
TEMPERATURE RECORDER (THERMOCOUPLE)

FIG. 7 STROKING TEST APPARATUS

or oven having sufficient capacity to house the three wheel cylinder fixture assemblies, master cylinder, and necessary connections. A suitable thermostatically controlled heating system is required to maintain a brake fluid temperature 120 ± 5°C. Heaters shall be shielded to prevent direct radiation to wheel or master cylinders. Fluid temperatures shall be monitored at random intervals during the test at the master cylinder reservoir using a temperature recording device.

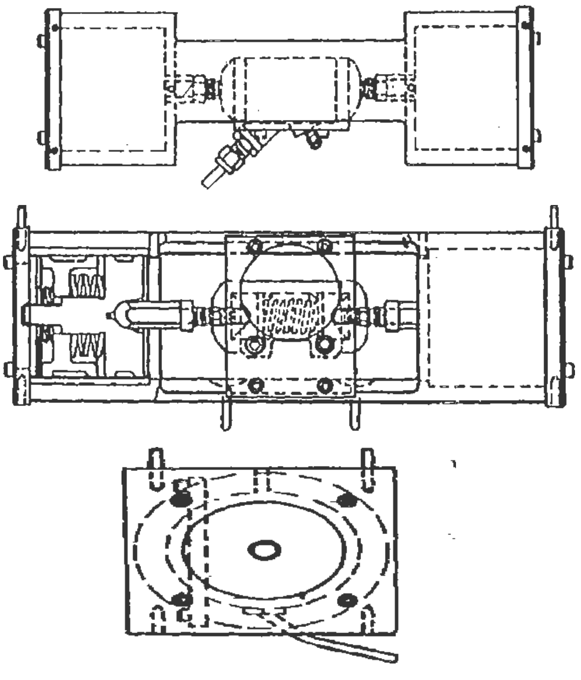


FIG. 8 STROKING FIXTURE APPARATUS

M-3 PREPARATION OF TEST APPARATUS

M-3.1 Wheel Cylinder Assemblies

Use new wheel cylinder assemblies having pistons made from steel (**E-3.1**). Disassemble cylinders and discard rubber cups. Clean all metal parts with *iso*-propanol and dry with clean compressed air. Inspect the working surfaces of all metal parts for scoring, galling or pitting and cylinder bore roughness and discard all defective parts. Remove any stains on cylinder walls with lint-free cloth and *iso*-propanol. If stains are not removed, discard the cylinder,

M-3.1.1 Measure the internal diameter of each cylinder at locations approximately 19 mm from each end of cylinder bore, taking measurements in line with the hydraulic inlet opening and at right angles to the centre line. Discard the cylinder, if any of these four readings differ by more than 0.08 mm. Measure the outside diameter of each piston at two points approximately 90 degrees apart. Discard any piston if either reading differ by more than 0.04 mm. Select parts to ensure that the clearance between each piston and mating cylinder is within 0.08 to 0.13 mm.

M-3.1.2 Use new hydraulic standard SBR rubber cups (Annex E) that are free of lint and dirt. Discard any cup showing imperfections, such as cuts, tooling marks, moulding flaws or blisters. Measure the lip and base diameter of all test cups with an optical comparator or a micrometer to the nearest 0.025 mm along the centre line and at right angles to this centerline. Determine base diameter measurements within 0.8 mm of the bottom edge and parallel to the base of the cup. Discard any cup if the two measured lip or base diameter differ by more than 0.08 mm. Average the lip and base diameters of each cup. Determine the hardness of all cups by the procedure prescribed in IS 3400 (Part 2). Clean rubber parts with *iso*-propanol and lint free cloth. Dry with clean, compressed air.

Dip the rubber and metal parts of the wheel cylinders, except housings in the fluid to be tested and install them in accordance with the manufacturer's instructions. Rubber boots may be retained on the cylinders if a small section is removed on the bottom to observe leakage. Manually stroke the cylinders to ensure that they operate easily. Install cylinders in the simulated brake system.

M-3.2 Master Cylinder Assembly

Use new master cylinder having a piston made from steel and new hydraulic SBR cups (*see* Note) which have been inspected, measured and cleaned in manner specified in **M-3.1**. Remove any burrs or wire edges from the relief and supply ports of the master cylinder. Measure the internal diameter of the cylinder at two locations; approximately midway between the relief and supply ports and approximately 19 mm beyond the relief port towards the bottom or discharge end on the bore, taking measurements at each location on the vertical and horizontal centerlines of the bore. Discard the cylinder if any of these four readings differ by more than 0.08 mm. Measure each of the outside diameter of the master cylinder piston at two points approximately 90 degrees apart. Discard any piston if reading differs by more than 0.04 mm. Dip the rubber and metal parts of the master cylinder, except housing, in the fluid to be tested and install them in accordance with manufacturer's instructions. Discard boot and push rod assembly. Manually stroke the master cylinder to ensure that it operates easily. Install the master cylinder in the simulated brake system.

NOTE — Part No. BI Girling 64674047, by M/s Brakes India Ltd, Padi Chennai 60050 or equivalent.

M-3.3 Assembly and Adjustment of Test Apparatus

Install wheel and master cylinders. Fill the system with test fluid, bleeding all wheel cylinders and the pressure gauge to remove entrapped air from system.

M-3.3.1 Operate the actuator manually to apply a pressure more than the required operating pressure and inspect the system for leaks. Adjust the actuator to obtain a pressure of 6.86 ± 0.343 MPa (70 ± 3.5 kgf/cm^2) and a smooth pressure-stroke pattern. Adjust the rate to 1000 ± 100 strokes per hour. Record the fluid level in master cylinder stand pipe at 23 ± 5°C with the master cylinder piston in the fully returned position.

M-4 TEST PROCEDURE

M-4.1 Operate the system for 16 000 ± 1 000 cycles at 23 ± 5°C. Repair any leakage and add fluid to master cylinder stand pipe to bring to the level originally recorded at the same temperature with the piston fully returned.

M-4.2 Start the test again and raise the temperature of the fluid in the master cylinder within 6 ± 2 h to 120 ± 5°C. During test, observe operation of the master cylinder for complete piston return and wheel cylinders for proper operation. Observe fluid level in relation to the room temperature level at random intervals. Continue the test to 85 000 total recorded strokes which shall include the number of strokes during operation at 23 ± 5°C the number of strokes required to bring the system to the operating temperature of 120 ± 5°C plus the number of strokes at this operating temperature. Stop the test and with the master cylinder piston in the fully returned position to relive retained pressure in the system, allow the equipment to cool to room temperature. Record-the amount of fluid required to replenish any loss of fluid to the 23 ± 5°C level originally record. Stroke the assembly an additional 100 strokes at 23 ± 5°C and 6.86 ± 0.343 MPa (70 ± 3.5 kgf/cm^2), examine wheel cylinders for leakage, and add and record volume of fluid required to bring the fluid level to the 23 ± 5°C original level.

M-4.3 Within 16 h remove the master and wheel cylinders from the system, retaining the fluid in the cylinders by immediately capping or plugging the ports. Disassemble the cylinders, collecting the fluid from the master cylinder and wheel cylinder in a glass jar. Record any sludge, jell or abrasive grit present in the test fluid. When collecting the stroked fluid, the entire residue, which has deposited on the rubber and metal internal parts, should be removed by rinsing and agitating such parts in the stroked fluid and using a soft brush to assure that all loose adhering sediment is collected. Clean rubber cups in *iso*-propanol and dry with clean compressed air, inspect cups for tackiness, scoring, scuffing, blistering, cracking, chipping (heel abrasions) and change in shape from original appearance. Within 1 h after disassembly, measure the lip and base diameter of each rubber cup by the procedure specified in **M-3.2** with the exception that the lip of base diameters of cups may differ by more than 0.08 mm. Determine the hardness of each cup. Within 1 h after draining cylinders, agitate fluid in glass jar to suspend and uniformly disperse sediment and transfer a 100 ml portion of this fluid to an ASTM cone-shaped centrifuge tube and determine percent sediment as described in IS 1448 [P : 41]. Inspect cylinder parts, recording any gum deposits. Rub any deposits adhering to cylinder walls with a cloth wetted with *iso*-propanol to determine abrasiveness and removability. Clean cylinder parts in *iso*-propanol and dry with compressed air, and inspect for pitting and scoring on pistons and cylinder walls. Measure and record diameters of pistons and cylinders by the procedures specified in **M-3.1** and **M-3.2**.

Calculate lip diameter interference set by the following formula:

$$\text{Lip diameter interference set, percent} = \frac{(D_1 - D_2)\times 100}{(D_1 - D_3)}$$

where

D_1 = original lip diameter,
D_2 = final lip diameter, and
D_3 = original cylinder bore diameter.

Repeat the test if mechanical failure occurs that may affect the evaluation of the test fluid.

M-5 PERFORMANCE REQUIREMENTS

The brake fluid, when examined as prescribed in **M-4.3** shall meet the following performance requirements:

a) Metal parts shall not show corrosion as evidenced by pitting to an extent discernible to the naked eye, but staining or discoloration shall be permitted.
b) The initial diameter of any cylinder or piston shall not change by more than 0.13 mm during test.
c) Rubber cups shall not decrease in hardness by more than 15 degrees and shall not be in an unsatisfactory operating condition as evidenced by excessive amounts of tackiness, scoring, scuffing, blistering, cracking, chipping (heel abrasion), or change in shape from original appearance.
d) The base diameter of the rubber cups shall not increase by more than 0.9 mm.
e) The average lip diameter interference set of the rubber cups shall not be greater than 65 percent.
f) During any period of 24000 strokes, the volume loss of fluid shall not be more than 36 ml.
g) The cylinder pistons shall neither freeze nor function improperly throughout the test.
h) The volume loss of fluid during the 100 strokes at the end of the test shall not be more than 36 ml.
j) The condition of the fluid at the end of test as evidenced by sludging, gelling, or grittiness shall not be such as would be likely to cause improper brake action in actual service, and the sedimentation shall not exceed 1.5 percent by volume after centrifuging.
k) No more than a trace of gum shall be deposited on brake cylinder walls or other metal parts during test. Brake cylinder shall be free of deposits which are abrasive or which cannot be removed with a cloth wetted with *iso*-propanol.

ANNEX N

BIBILOPGRAPHY

ASTM	*Title*
D 7042 : 2016	Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer and the Calculation of Kinematic Viscosity.

ANNEX P

COMMITTEE COMPOSITION

Lubricants and their Related Products Sectional Committee, PCD 25

Organization	*Representative(s)*
Gulf Oil Lubricants India Ltd, Mumbai	Dr Y. P. Rao (***Chairman***) Shri Girish Jange (*Alternate*)
Ashok Leyland Ltd, Chennai	Shri D. Balakrishnan Shri Ravi M. (*Alternate*)
Bajaj Auto Ltd, Pune	Shri K. Rajan Shri Deepesh Mutke (*Alternate*)
Balmer Lawrie & Co Ltd, Kolkata	Dr Balaram. Ghosh Dr M. L. Das (*Alternate*)
Bharat Petroleum Corporation Ltd, Mumbai	Shrimati Seema Thakoor Dr A. Rajendiran (*Alternate*)
Castrol India Ltd, Mumbai	Shri Ashish Gondal Shri Raman Rai (*Alternate*)
Centre for High Technology, New Delhi	Shri Brijesh Kumar Shri Sushobhan Sarkar (*Alternate*)
Chennai Petroleum Corporation Ltd (CPCL), Chennai	Shri S. Kumar H. Ramakrishnan (*Alternate*)
Central Pollution Control Board, (Ministry of Environment & Forests), New Delhi	Shri Dinabandhu Gouda Shri B. K. Jakhmola (*Alternate*)
Consumer Guidance Society of India, Mumbai	Dr Sitaram Dixit Dr M. S. Kamath(*Alternate*)
Hero Moto Corp Ltd, Gurgaon	Shri Ajay Gupta
Hindustan Petroleum Corporation Ltd, Mumbai	Shri K. K. Banerjee Shri Abhijit Sarkar (*Alternate*)
Indian Additives Ltd, Chennai	Shri Aanish Dwarkadas Shri Srikanthan (*Alternate*)
Indian Institute of Petroleum, Dehradun	Dr A. K. Jain Shri G. D. Thakre (*Alternate*)
Indian Oil Corporation (R & D), Faridabad	Dr Deepak Saxena Dr Pankaj Bhatnagar (*Alternate*)
Indian Oil Corporation Ltd, (Marketing Division), Mumbai	Shri Sanjeev Kundu Dr A. S. Kathait (*Alternate*)
Indian Oil Corporation Ltd., (Refineries), New Delhi	Shri Ashwani Sharma Shri R. K. Chugh (*Alternate*)
Lubrizol India Ltd, Mumbai	Shri Anand Redkar Shri D. S. Padmanabhan (*Alternate*)
Mahindra & Mahindra Ltd, Chennai	Shri R. Ramaprabhu
Maruti Udyog Ltd, Gurgaon	Shri Ashok Permude Shri Narinder Kumar (*Alternate*)
DRDO, Ministry of Defence, Ahmednagar (Maharashtra)	Shri C. V. Pandey
RDSO, Ministry of Railways, Lucknow	Shri Rajesh Srivastava Shri Sonam Gupta (*Alternate*)

Organization	*Representative(s)*
Ministry of Road Transport & Highways, New Delhi	Shri G. Sharan Shri S. S. Nahar (*Alternate*)
Bosch Ind Ltd, Bengaluru	Shri A. Fredrick Shri D. Ramaraju (*Alternate*)
National Test House, Kolkata	Dr S. N. Bandyppadhyay Dr Umesh Singh (*Alternate*)
Reliance Industries Limited, Mumbai	Shri Advait Anaspure
Society of Indian Automobile Manufacturers, New Delhi	Shri P. K. Banerjee Shri Atanu Ganguli (*Alternate*)
Steel Authority of India Ltd, New Delhi	Shri G. Chakravarti
Swastik Oil Products Mfg Co Pvt Ltd	Shri Bhupendra Rathod Shri Sanat Rathod (*Alternate*)
Tata Motors Ltd, Pune	Shri P. B. Dakhole Shri S. B.Gudekar (*Alternate*)
The Automotive Research Association of India (ARAI), Pune	Dr S. S. Thipse
TVS Motor Company Ltd, Hosur, Tamil Nadu	Shri Ajith Kumar
Afton Chemicals, Mumbai	Shri Jeenal Patel
FSSAI, New Delhi	Nominated Awaited
DGMS, Dhanbad	Nominated Awaited
NETRA	Shri P. K. Jain
BHEL (R & D), Hyderabad	Nominated Awaited
SAIL, Ranchi	Shri Anujit Rituraj Shri Balakrishna Bisoyi (*Alternate*)
ISMA	Nominated Awaited
BASF India Limited	Ms Anju Sharma Shri Ashok Sambandam (*Alternate*)
PCRA	Surendra Pratap Shri M. P. Bangwal (*Alternate*)
Director General, BIS)	Shri V. K. Diundi, Scientist 'F' and Head (PCD) [Representing Director General (*Ex-officio*)]

Member Secretary

Shrimati Nagamani T.
Scientist 'D', BIS

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Subcommittee, PCD 25 : 1

Organization	*Representative(s)*
Indian Oil Corporation (R & D), Faridabad	Dr Deepak Saxena (***Convener***)
Ashok Leyland Ltd, Chennai	Shri Ravi M. Shri D. Dhanasekaran (*Alternate*)
Association of State Road Transport Undertakings, Mumbai	Nominations to be ascertained

Organization	*Representative(s)*
Afton Chemical, Mumbai	Shri Anand Kumar Shri Jeenal Patel (*Alternate*)
Bajaj Auto Limited, Pune	Shri K. Rajan
Balmer Lawrie & Co Ltd, Mumbai	Dr Balaram Ghosh Dr M. L. Das (*Alternate* I) Shri Rohit Agarwal (*Alternate* II)
Bharat Petroleum Corporation. Ltd, Mumbai	Mrs Seema D. Thakoor Dr M. Rajendiran (*Alternate*)
BASF India Limited	Shri Anju Sharma Shri Ashok Sambandam (*Alternate* I) Shri Manthan Sanghavi (*Alternate* II)
Castrol India Ltd, Mumbai	Shri Ashish Gondal Shri Raman Rai (*Alternate*)
Central Institute of Road Transport, Pune	Shri N. R. Tiwari Shri R. N. Gore (*Alternate*)
Consumer Guidance Society of India, Mumbai	Dr Sitaram Dixit Dr M. S. Kamath (*Alternate*)
Controllerate of Quality Assurance Petroleum Products (CQAPP), Kanpur	Shri R. S. Diwakar Shri G. S. Lal (*Alternate*)
Escorts Ltd, Faridabad	Nominations to be ascertained
Exxon Mobil, Gurgaon	Nominations to be ascertained
Gulf Oil Lubricants India Ltd, Mumbai	Shri Sanjay Kumar Ms Indu M. Gupta (*Alternate*)
Hero Moto Corp Ltd, Gurgaon	Shri Harjeet Singh Shri Ashok Kataria (*Alternate*)
Hindustan Petroleum Corporation Ltd, Mumbai	Shri K. K. Banerjee Shri Abhijit Sarkar (*Alternate*)
Indian Additives Ltd, Chennai	Shri Aanish Dwarkadas Shri Srikanthan (*Alternate*)
Indian Institute of Petroleum, Dehradun	Dr Manoj Srivastava Shri Devendar Singh (*Alternate*)
Indian Oil Corporation (R & D), Faridabad	Dr Sarita Garg Dr Sarita Seth (*Alternate*)
IOC Ltd (Marketing Division), Mumbai	Shri S. Venkatesan Shri Nitish Mittal (*Alternate*)
LML Ltd, Kanpur	Nominations to be ascertained
Lubrizol India Ltd, Mumbai	Dr Anand Redkar Shri D. S. Padmanabhan (*Alternate*)
Mahindra & Mahindra Ltd, Nasik	Shri R. Ramaprabhu
Maruti Ugyog Limited, Gurgaon	Nominations to be ascertained
RDSO, Lucknow	Shri A. K. Sabharwal Dr K. Konar (*Alternate*)
Reliance Industries Limited, Mumbai	Shri Vijay Upadhyay
Society of Indian Automobiles Manufacturers (SIAM)	Shri P. K. Banerjee Shri Atanu Ganguli (*Alternate*)
Shell Industries	Shri Siva Kasturi
TATA Cummins Ltd, Jamshedpur	Nominations to be ascertained

Organization	*Representative(s)*
TATA Motors Ltd, Pune	Shri S. R. Ponkshe Shri V. R. Jalgaonkar (*Alternate*)
The Automotive Research Association of India (ARAI), Pune	Dr S. S. Thipse Shri S. V. Shete (*Alternate*)
Tide water	Shri Jaideeep M. Sarnaik Shri C. S. Balamurugan (*Alternate*)
Vinni Chemicals Pvt Ltd	Shri Harsh Vardhan Jain
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